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THE UNIVERSITY OF ALBERTA

A STUDY OF PHYSICAL SCIENCE LABORATORY FACILITIES IN SENIOR HIGH SCHOOLS IN ALBERTA

by

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A THESIS

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ABSTRACT OF THE THESIS

A survey was made of the laboratory science facilities in one hundred eighty senior high schools in Alberta. To carry out this survey a questionnaire was prepared and distributed in May, 1962 to a list of approved secondary schools. The data on the returned questionnaires were tabulated and treated mathematically so that assessments and conclusions could be made.

A major purpose of the study was to obtain information on the dominant type of space facility used for teaching the high school physical sciences. It was found that the physical science laboratory was most common. An encouraging factor was that almost one-third of the science rooms were of the combined classroom and laboratory type. The large schools had the highest proportion of designated physics and chemistry laboratories. There seemed to be a sufficient number of science rooms in the smaller high school, while some of the larger ones were under the minimum requirements.

It appeared that provision of some of the ancillary laboratory facilities was minimally adequate. For instance, the number of laboratory stations provided per science room appeared to be adequate in most schools for pupils working in the laboratory in groups of two or more. On the average, the essential utilities were also minimally adequate relative to the number of stations. Other types of furnishings such as wall storage, demonstration desks, and fume hoods appeared to be adequately provided. However, ancillary rooms such as

storage rooms seemed to be required in many of the schools. More attention should be given to safety.

It was hoped that an assessment could be made regarding the adequacy of the present laboratory facilities for teaching the present physical science program as well as future programs which might require more extensive laboratory work. This was impossible to do since little research evidence was available on which to make even qualitative assessments. However, there does appear to be a serious need for more direction in the future planning of science facilities in senior high schools in Alberta.

ACKNOWLEDGEMENTS

I wish to express my grateful appreciation to the members of my committee, Mr. M. A. Nay (chairman), Mr. C. St. John, Dr. S. Trieger, and Mr. V. R. Nyberg, for their patient guidance, and their critical and valuable observations. To all those others who contributed so generously either directly or indirectly, my sincerest thanks

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

Recent scientific and technological developments have resulted in a demand for a better quality of science program in the secondary school, and have given impetus to the teaching of science in the elementary grades. The challenge facing the science teacher, curriculum planner, educator and scientist is the need to develop new science programs for all grade levels.

Many critics have underlined the need for subjecting the science curricula to drastic revision. Hurd[1] has this to say:

> Science teaching in secondary schools is due for a series of major educational changes during the next decade or so. The age of science is making it mandatory that all students develop some competencies in science. The impact of science on our social and cultural development is adding new objectives and purposes to science teaching. The new curriculum in science will be one structured to increase man's adjustment to and control over his biological, physical, and social world . . . . It seems desirable that the entire program of science teaching should be re-examined before the tremendous impact of increased enrollments now in the elementary school reaches the high school.

What is the state of science education in the schools of Alberta today? The revision of the science programs for Grades I to

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[1] Paul DeH. Hurd, Science Facilities for the Modern High School, Education Administration Monograph No. 2, School of Education, Stanford University, 1954, p. 24.

IX has been completed. A revised Science 10 program for Grade X appeared in 1960, and the new Science 12 course was introduced in 1961. Revisions are being considered in Science 20 at the Grade XI level, and in physics, chemistry and biology at the Grade XII level. A new biology course for Grade XI is in the planning stage.

The perturbing feature of this revision is its apparent lack of direction. Direction in the first instance must come from a set of objectives for the teaching of science. That is, adoption of rational objectives should guide the planning of science programs. For example, the objectives stated in The Bulletin of the National Association of Secondary-School Principals[2] would be invaluable in guiding the curriculum planner in science. Since current objectives place heavy stress on inductive thinking and learning, both in the classroom and laboratory, sound science programming requires that considerable thought be given to the facilities required to implement the programs. It can be unequivocally stated that facilities should be planned in terms of the program offered.

The Changing Role of Laboratory Activity in Science Teaching

Studies, originating in the United States, have all spoken of "new trends" in science education and about facilities to implement

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[2] The Bulletin of the National Association of Secondary-School Principals. Volume 44, Number 260, December 1960, pp. 42-43 and pp. 77-87.

these trends. The main trend in science teaching is towards the type of science course in which laboratory work is an essential part of the student's experience.

For instance, Dr. Glenn Seaborg[3] indicates the new role of laboratory work in the Chemical Education Materials (CHEM) Study in these words:

> It was decided from the very beginning to have the high school chemistry course strongly based in experiment, and to have the text thoroughly dependent upon and integrated into the laboratory experiments, with the supplemental use of integrated films wherever they might be helpful.

Also, J. A. Campbell[4] of the CHEM Study group said that

> the materials developed so far have a strong laboratory emphasis, and approach chemistry from the standpoint of the important concepts which a chemist uses, rather than the isolated bits of information which can be acquired from studying purely descriptive chemistry.

The Committee that prepared CHEM Study was concerned about the general student. Seaborg[5] indicates this as follows:

> Another basic tenet was to make the course applicable to the general student who takes high school chemistry rather than to the gifted or upper part of the typical high school class. It was proposed that the talented student be helped through the preparation of the supplemental material for use in the text, perhaps as fine print, and providing additional experiments.

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[3]Glenn T. Seaborg, "New Currents in Chemical Education", Chemical and Engineering News, Vol. 38, Oct. 17, 1960, p. 17.

[4]J. A. Campbell, Science Education News, American Association for the Advancement of Science, Washington 5, D.C., December 1961, p. 5.

[5]Seaborg, loc. cit. p. 17.

In the past, the course content and laboratory work were patterned largely to prepare the high school student for college work in science. Over the years a traditional pattern of laboratory "experiences" developed. It is now claimed that for the vast majority who do not plan to specialize in scientific and technical fields the traditional patterns are too limiting. Facilities for teaching the physical sciences should make possible learning activities for all students.

Three other courses which have made an effort to break away from the traditional programming of science are the Physical Sciences Study Committee (PSSC) physics,[6] the Chem Bond Approach (CBA) chemistry,[7] and the Biological Sciences Curriculum Study (BSCS) biology. In the CBA,

> the laboratory experiments are presented as problems and, insofar as possible, the student is encouraged to decide what information and techniques he needs to solve each problem.

An excerpt from the laboratory manual for the PSSC physics states that

> students can investigate physical phenomena rather than just verifying known conclusions. When a student performs experiments, the results of which are not known to him in advance, he gains a feeling of personal participation in the discoveries of science; both science and the role of the scientist become more meaningful to him.

All three courses have been taught in many selected high schools in the United States, and the PSSC physics is at present being taught in selected high schools in Alberta.

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[6]Physical Science Study Committee: Laboratory Guide for Physics, D. C. Heath and Co., 1960, p. iv.

[7]Laurence E. Strong, Science Education News, American Association for the Advancement of Science, Washington 5, D.C., December 1961, p. 5.

British science educators have also been concerned about science experimentation because laboratories and laboratory work have not always been a part of the curriculum. Science in Secondary Schools[8] gives this description of science teaching in England in the 1880's:

> Pupils were confined to the classroom, and even the opportunity for studying nature out of doors was not taken. From the kinds of answers to the questions that were obtained in the examinations, it appeared that a very large part of the instruction was derived from books, tested and aided by class examinations by the teachers . . . .

A vigorous critic of these methods in science was Professor H. E. Armstrong[9] who occupied the Chair of Chemistry in the Finsbury Technical College. He had become alarmed over the lack of scientific training his students received before joining the College. The schemes he put forward to improve the teaching were adopted. His aim was to develop "scientific habits of mind; thoughtfulness and power of seeing; accuracy of thought, word and deed". He was a great advocate of weighing and the use of the chemical balance.

The Need for the Study

Ideally, facilities for teaching new science programs should be planned on the basis of sound research evidence. However, few

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[8]Ministry of Education Pamphlet, No. 38, Science in Secondary Schools, Her Majesty's Stationery Office, London, 1960, p. 16.

[9]Ibid.

dependable studies on science facilities are available. The following comment is made in the Encyclopedia of Educational Research.[10]

> It is a commonly accepted principle that equipment and facilities should be planned in terms of the educational program. Modern educational theory, with its emphasis on flexibility and the wide use of various library, multi-sensory, and demonstration equipment, has obvious implications for the kind of facilities which should be provided. In view of the immense sums of money which have been expended recently and are likely to be spent at an accelerating rate in the next decade for facilities for science instruction, one is impressed by the paucity of educational research directed toward objective evaluation of facilities of various types.
>
> Few comprehensive approaches to the study of facilities for science instruction seem to have been made. Three early studies have been reported; these are more than 25 years old, and educational philosophy and theory have modified the concept of an adequate school building since that time. More recently three excellent monographs have appeared. School Facilities for Science Instruction presents a great many ideas that would be exceedingly valuable to anyone remodelling or planning science facilities. Nevertheless, many of the ideas proposed have not been thoroughly studied on an objective basis.

Since this commentary was made, several more studies on science facilities have been published in the United States and England. Since no comparable studies have been reported for Alberta, a summary of findings in these new studies might be of value.

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[10] The American Educational Research Association, Encyclopedia of Educational Research, The Macmillan Co: New York, 1960, p. 1226.

An investigation[11] of science laboratories made in 1955 in England revealed that over one-third of the laboratories in the modern schools in the sample visited were converted classrooms, almost all of which were inadequate in size, permitting practical work to be performed by the pupils only in uneconomically small classes and even then with some difficulty. In a few of the newest schools there were good facilities for storage, but frequently quite inadequate storage seriously limited the nature of the work which could be done. Today, an extensive building program has produced, and is producing, many new school buildings; and invariably there is included at least one good laboratory in each of these. Many schools, however, have grown so that their laboratories are now insufficient in number.

That the subject of science rooms and facilities has been of concern is shown in the foreword to the study, Science and Mathematics in Public High Schools, 1958.[12]

> The Congress of the United States, in passing the National Defense Act of 1958, reflected an ever increasing desire on the part of the Nation to improve the teaching of science and mathematics in its schools.
>
> The lack of adequate facilities and equipment had long been considered a major handicap to effective science and mathematics instruction. Practically no data were available, however, to indicate the specific kinds of equipment that were lacking, or to judge the adequacy or inadequacy of facilities in public high schools of different types and sizes.

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[11] Ministry of Education Pamphlet, No. 38, Science in Secondary Schools, Her Majesty's Stationery Office, London, 1960, p. 16.

[12] Obourn and Koelsche, Science and Mathematics in Public High Schools, Part I, General Facilities and Equipment, U.S. Department of Health, Education and Welfare, Office of Education, 1958, p. iii.

Information supplied by the 2,210 science teachers included in this survey[13] covered the following: types of rooms used for science teaching, facilities, equipment and adequacy of equipment. No particular recommendations were made in this study.

More specific reference to changes in facilities and the replacements being made in these facilities appears in Facilities and Equipment for Science and Mathematics.[14] This is a collection of the official requirements and recommendations of State departments of education in regard to facilities, equipment, and instructional material for science and mathematics at all levels in the public schools in the United States. Of the many States reporting, excerpts from the requirements for high schools of four of the States are given here.

Alabama: Better School Buildings for Alabama, 1949.

> The planning of a new science unit provides an opportunity to further the development of a truly modern science program. The facilities provided can either contribute to or hinder its development. Every effort should be made to plan the needed space and equipment for a large variety of individual and group activities that are now considered an essential part of the science program.

Florida: Florida School Facilities Conference, 1956.

> In the past, science facilities have consisted of a laboratory room, storage rooms and a classroom. Only one

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[13] Obourn and Koelsche, op. cit. pp. 4-19.

[14] W. Edgar Martin, Facilities and Equipment for Science and Mathematics, Misc. No. 34, U.S. Government Printing Office, Washington, 1960.

> of these large rooms was used at a time by the class, i.e., either the "lab" or the "lecture" room. Current science teaching has made this layout obsolete.
>
> Michigan: Planning Together for Better School Building, 1956.

> Even in large schools, multipurpose laboratories are finding increased acceptance when adequate facilities for storage of materials and supplies are provided. Increased attention is being given to flexibility of all kinds of science rooms in high schools. Separate "lecture" rooms are no longer advocated and arrangement of laboratory tables around the perimeter of the rooms is becoming more common.
>
> Minnesota: Guide for Educational Planning of Public Buildings and Sites in Minnesota, 1957.

> In the past years, the traditional arrangement for science courses consisted of separate rooms, one or more for lectures, demonstration, and recitation, and one for experimentation and laboratory work by pupils. Over the years, this arrangement gave way to a single classroom-laboratory, in which one area of the room was equipped for presentation, demonstration, and recitation and another area for laboratory work by pupils.

Koelsche[15] reported a study, made in 1958-59 of a sample of 855 high schools selected at random from three, four and six year high schools operating during the 1958-59 academic year in Florida, Illinois, Massachusetts, North Dakota, Ohio, South Carolina and Wisconsin. Analysis was made of types of rooms, and miscellaneous facilities in science classrooms. About the types of rooms, Koelsche had this to say:

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[15]Charles F. Koelsche and Archie N. Solberg, Facilities and Equipment Available for Teaching Science in Public High Schools, Research Foundation, University of Toledo, Toledo, Ohio, 1959, p. 66.

> Combination classrooms and laboratories (multipurpose rooms) are becoming the most popular type of facility for science instruction, thus replacing the traditional separate lecture and laboratory rooms so common during the first half of this century. Entirely too many high schools, however, were still using regular classrooms for science classes because their facilities did not include enough rooms equipped specifically for science work.

Although comparable studies to those mentioned above have not been made for Alberta, Charyk,[16] in an unpublished B. Ed. thesis on methods used in improving the teaching of chemistry in Chinook School, has described facilities used in his own laboratory. These are the laboratory table, sink equipment, fume hoods, the balance table and the wash corner. He has also a chapter on safety in the laboratory. To a certain extent he has described some aspects of other laboratories in Alberta schools. He has concentrated mainly, though, on costs of maintaining his laboratory, and on the means of improving the teaching of the Chemistry II* course.

The annual reports of the Alberta Department of Education make only passing reference to laboratory facilities. The Fifty-fifth Annual Report[17] says this:

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[16] J. C. Charyk, A Survey of Difficulties Encountered in Laboratory Chemistry in Alberta Schools with Suggested Solutions as Evidenced from a Four Year Experiment Conducted in Chinook High School. Unpublished B. Ed. Thesis, University of Alberta, 1942.

[17] Province of Alberta, Fifty-fifth Annual Report of the Department of Education, published by order of the Legislative Assembly. Queen's Printer, 1960, p. 47.

* Chemistry II, former designation used for Grade XII Chemistry.

> Laboratories tend to be outdated; opinion was expressed that new science courses require subject laboratories, greater accommodation, and extensive facilities for the use of both junior and senior high school students. A few superintendents commended the large combined instruction and laboratory science rooms.

On the same matter, little was said by The Report of the Royal Commission on Education published in 1959.[18]

> In the last decade or so there has been a notable improvement in the quality and provision of laboratories for physics and chemistry . . . . The function of the school laboratory has remained somewhat vague in spite of better provision.

It can now be said that the function of the school laboratory no longer is vague. It must serve as an area for achieving objectives of science instruction which go beyond the assimilation of science knowledge. If the provision of science facilities is improved in Alberta, as the Commission Report suggests, the question still remains: What are these facilities, and to what extent can they meet the demands for teaching new science programs based on increased laboratory experience? This study attempts to provide some of the answers.

The Nature and Purposes of the Study

This is a descriptive study of the laboratory facilities for teaching the physical sciences available in Alberta High Schools for the school year 1961-62. The physical sciences are Science 10, Science 12, Science 20, Chemistry 30 and Physics 30. Facilities

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[18]Province of Alberta, Report of the Royal Commission on Education, Queen's Printer, 1959, pp. 250-251.

include laboratory rooms, permanent fixtures and utilities in these rooms, supplementary rooms and apparatus and materials required to carry out demonstrations and experiments. Equipment to carry on experimental work is not considered in this study, not because it is not important, but because it is fairly easy to acquire when needed, and also because it is necessary to limit the study.

The purposes of this study are as follows:

1. To obtain information on the following aspects of the science facilities:

(a) The dominant types of space facilities.

(b) The provision of supplementary facilities.

2. To derive some judgments as to the standards and adequacy of these facilities in terms of area per student, number of laboratory stations, and enrollments in the physical sciences.

3. To attempt to evaluate the adequacy of the present laboratory facilities for teaching the present physical science programs and those involving more extensive laboratory experiences.

4. To obtain information on the extent to which laboratory facilities are used at present.

CHAPTER II

METHOD OF INVESTIGATION

A questionnaire (Appendix A) was prepared for the purpose of gathering information on the laboratory facilities provided in Alberta High Schools for teaching the physical sciences. Schools were chosen from a list of approved secondary schools prepared by the Department of Education from the Form A[1] card submitted by principals. The questionnaire and a self-addressed envelope were mailed on May 26, 1962. By this date most laboratory work had been done, and science teachers would have had opportunity to assess fully the facilities with which they had worked during the school year. Principals and science teachers in the selected schools were asked to complete the questionnaire and return it to the author for tabulation and analysis.

Four hundred high schools were on the approved list in 1961-62, of which twenty-one were situated in Edmonton and Calgary, and nineteen were private schools from various parts of Alberta. There were also a few schools in the Northwest Territories using the senior high school program of the Alberta Department of Education.

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[1] Senior High School Handbook 1961-62, Department of Education, Province of Alberta, Queen's Printer, p. 22.

Using the list of approved secondary schools and the Form A cards, the prepared questionnaires were sent to schools meeting these criteria:

1. They had the approval of the Department of Education.
2. They were in the province of Alberta.
3. They offered subjects in Grade XII.
4. They offered chemistry and/or physics.

Selecting schools in which Grade XII was taught insured that the laboratory facilities would be such as to handle, at least minimally, the Grade XII sciences. This meant, also, that other sciences must be taught as prerequisites.

The number of schools meeting these criteria was two hundred sixty-six. This was not a sample but represented all the schools meeting the stated criteria. Sampling was unnecessary as the number of schools was not too great to have all of them included.

The Form of the Questionnaire

The questionnaire consisted of the following items:

1. A letter to the principal of the school.
2. General instructions for filling out the questionnaire.
3. (a) General information on enrollment and organization.
   (b) Data form on laboratory space facilities and their use.
   (c) Data form on the number of permanent fixtures, furniture, adjoining rooms or areas.
   (d) Data form on the condition of the facilities found in science rooms.

4. Blank page for a sketch of the physical science laboratory or laboratories.

The main areas of information which the questionnaire was designed to obtain were as follows:

1. Enrollment in each of the physical science classes taught in the school.

2. The type and size of science rooms provided in the school.

3. The nature and number of ancillary facilities provided, such as utilities, furniture and auxiliary rooms.

4. Teacher reaction to adequacy of rooms and furniture.

5. Teacher reaction to general laboratory conditions such as heating, lighting and safety.

Definition of Types of Science Rooms and Laboratories

In this survey, five types of physical science rooms and laboratories were used to classify the space facilities found in Alberta schools. These were: the "modified" classroom with some laboratory facilities; the combined classroom and laboratory; the physical science laboratory; the designated physics laboratory, and the designated chemistry laboratory. These rooms were defined in terms of the functions for which they were intended.

1. The modified classroom is an ordinary classroom provided with some laboratory facilities. There may be a demonstration table with gas and water outlets. There may also be some pupil activity tables.

2. The combined classroom and laboratory contains both seating accommodation for pupils taking science and facilities for laboratory activity. In this study this type of room will also be referred to as a "multipurpose science room".*

3. The physical science laboratory is designed specifically for laboratory work. It has no seating accommodation for classroom type of work. Furthermore, its use would not be limited to laboratory work in any single physical science.

4. The designated physics laboratory is intended for student laboratory activities in physics only. In it facilities are provided for experiments in mechanics, heat, light, sound, electricity, and magnetism.

5. The designated chemistry laboratory is intended for student laboratory activities in chemistry only. Fairly standard facilities in this type of laboratory are fume hoods, and numerous laboratory stations each provided with gas, water, electricity, and a sink.

It should be noted in conclusion that a laboratory which is separated from a science classroom by a wall, but which is accessible to it by a connecting door, may be either a physical science laboratory, a designated physics laboratory, or a designated chemistry laboratory.

Ancillary Laboratory Facilities

Ancillary laboratory facilities are those facilities, exclusive

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*Actually the term "multipurpose science room" is most commonly used to designate a combination classroom and laboratory, when it is used for instruction in all the science courses.

of space, which are deemed necessary for laboratory activity, storage, science projects, displays, preparations, safety and consultations. Exact numbers were asked for in regard to such items as: water and gas outlets, fume hoods, laboratory stations, fixed and movable tables, bulletin boards, chalkboards, safety devices, and auxiliary rooms such as storage rooms, dark rooms and office rooms. It was felt that indicating the exact number of each would give a better idea of the adequacy of ancillary facilities in the science room.

Teacher Reaction to Conditions in the Laboratory

To assist the writer further in judging the adequacy of the laboratory facilities, teachers were asked to indicate the condition of the furnishings in the science rooms. Such things as newness, need for replacement and flexibility of arrangement of furniture were placed in this section. Items asking for the opinion of teachers as to the adequacy of heat, light, ventilation and floor covering were added to give details which would help to complete the picture of the science room.

The Sketch

Teachers were asked to make a sketch of each of their science rooms and laboratories, and to indicate the dimensions of these rooms. These sketches provided a check on the information given in response to the questionnaire and thus minimized inadvertent errors owing to misunderstanding of possibly unfamiliar expressions such as: laboratory station, shower bath, or type of laboratory room. The information on

the dimensions of the science rooms and laboratories was used to obtain the area of space per pupil.

CHAPTER III

REPORT AND ANALYSIS OF DATA

The data on the returned questionnaires were tabulated and treated mathematically in order that the appropriate assessments and conclusions could be made. Simple mathematical analysis was applied throughout.

Distribution of Schools Participating in the Survey

The questionnaire was sent to the two hundred sixty-six schools meeting the four criteria in Chapter II, p. 14. Usable returns were received from one hundred eighty schools, or 68 per cent of the total. As can be seen from the map, Appendix B, completed questionnaires were received from all parts of the province.

Table I indicates the number, size and type of high schools participating in this survey. The schools were divided into five categories according to the number of pupils enrolled: 1 - 59, 60 - 99, 100 - 199, 199 - 499, 500 or more. According to Table I, almost three-quarters (72.2 per cent) of the secondary schools were located in villages and towns; the remaining one-quarter (27.8 per cent) of the schools were found in cities and hamlets, or were private schools.

It is rather unfortunate that completed questionnaires were received from only 51 per cent of the schools with enrollments

TABLE I

NUMBER OF SECONDARY SCHOOLS REPRESENTED
IN THE SURVEY BY SIZE OF SCHOOL

Type of High School	Size of High School						
	1-59	60-99	100-199	200-499	500 or more	Total	Per cent
Hamlet	17	4				21	11.7
Village	25	26	11			62	34.4
Town	7	16	30	14	1	68	37.8
City	2	3	3	6	10	24	13.3
Private	1		1	3		5	2.8
Total	52	49	45	23	11	180	100.0
Percentage of schools replying in each category	(62)	(71)	(75)	(72)	(51)	(68)	

of 500 or more pupils. However, a mitigating factor is that every large school system in the province, with the exception of Medicine Hat, is represented in this survey.

Physical Science Programs Offered

Table II shows the combinations of physical science courses offered in the schools in the survey. The table indicates that the larger the school the more physical science courses were offered. The four course program consisting of Science 10, Science 20, Chemistry 30 and Physics 30 was the most common, being offered in 69 (38.3 per cent) of the schools.

TABLE II

COMBINATIONS OF PHYSICAL SCIENCE COURSES OFFERED BY SIZE OF SCHOOL

Combination of Courses	Size of School					
	1-59	60-99	100-199	200-499	500 or more	Total
Science 10 Science 20	1					1
Science 10 Science 12 Chemistry 30	1					1
Science 10 Science 20 Chemistry 30	29	9	1			39
Science 10 Science 20 Physics 30		1				1
Science 20 Chemistry 30 Physics 30				1		1
Science 10 Science 20 Chemistry 30 Physics 30	14	24	19	10	2	69
Science 10 Science 12 Science 20 Physics 30	1					1
Science 10 Science 12 Science 20 Chemistry 30	3	3	2			8
Science 10 Science 12 Science 20 Physics 30 Chemistry 30	3	12	23	12	9	59
Total	52	49	45	23	11	180

Schools offering five physical science courses ranged from 6 per cent in the 1-59 category to 82 per cent in the 500 or more category. The schools which offered Science 10, Science 20 and Chemistry 30 were in the two lower categories; with 56 per cent of the schools in the 1-59 category and 18 per cent in the 60-99 category.

Enrollment

Table III gives the total enrollments in physical science courses according to size of school, and compares this with the total high school population represented in this survey. The table indicates that 84.7 per cent of the student population was enrolled in the physical science courses. Whereas the majority of the high schools (81 per cent) had enrollments below 200 pupils, (Table I), a majority of the pupils (58.4 per cent) were enrolled in secondary schools with enrollments of 200 or more. Similarly, almost half (48.4 per cent) of the enrollment in the physical sciences was in the larger schools (200 and more pupils). Significantly, 15.3 per cent of the pupils were not taking physical sciences at all.

Table IV compares the numbers of pupils enrolled in each of the physical sciences according to size of school. These figures show that generally the number of pupils enrolled, and the number of science classes, increased with the size of the schools. An exception appears in Science 10 and Science 12 for the 200-499 category. Here there is a drop both in number of classes and in enrollment. The number of pupils enrolled in each of the physical

TABLE III

NUMBER AND PER CENT OF PUPILS ENROLLED IN SCHOOL AND PHYSICAL SCIENCE COURSES BY SIZE OF SCHOOL

Enrollment	Size of School					
	1-59	60-99	100-199	200-499	500 or more	Total
School enrollment	2309	3747	6050	6607	10415	29128
Percent of total enrollment	7.9	12.9	20.8	22.7	35.7	100.0
Science class enrollment	2053	3291	5209	5175	8923	24651
Percent of total science class enrollment	8.3	13.4	21.1	21.0	36.2	100.0
Percent of total school enrollment taking science	7.1	11.3	17.9	17.8	30.6	84.7

sciences is approximately the same for each size of school when it is expressed as a percentage based on the total number of pupils enrolled in physical science courses. Science 10 and Science 20 in the 1-59 category have higher percentage enrollments than do other sizes of schools.

Total enrollments in each of the physical sciences decreases, except in Science 12, from a high of 35.7 per cent in Science 10 to a low of 9.1 per cent in Physics 30. There were more than twice as many students enrolled in Chemistry 30 as there were in Physics 30.

TABLE IV

NUMBER OF CLASSES AND NUMBER OF PUPILS
IN EACH OF THE PHYSICAL SCIENCES
BY SIZE OF SCHOOL

Physical Science	Size of School					
	1-59	60-99	100-199	200-499	500 or more	Total
Science 10						
Number of classes	52	52	80	61	98	343
Number of pupils	826	1250	1921	1660	3136	8793
Per cent of total*	40.2	38.0	36.9	32.1	25.1	35.7
Science 12						
Number of classes	8	18	25	17	24	92
Number of pupils	69	231	404	383	646	1733
Per cent of total	3.4	7.0	7.8	7.4	7.3	7.0
Science 20						
Number of classes	51	49	59	57	76	292
Number of pupils	647	896	1392	1411	2347	6693
Per cent of total	31.5	27.2	26.7	27.3	26.3	27.1
Chemistry 30						
Number of classes	51	48	52	54	63	268
Number of pupils	423	678	1037	1225	1827	5190
Per cent of total	20.6	20.6	19.9	23.6	20.5	21.1
Phyics 30						
Number of classes	18	35	42	26	36	157
Number of pupils	88	236	455	496	967	2242
Per cent of total	4.3	7.2	8.7	9.6	10.8	9.1
Total number of classes	180	202	258	215	297	1152
Total number of pupils	2053	3291	5209	5175	8923	24651
Average size of science class	11.4	16.3	20.2	24.1	30.0	21.4

*The number of Science 10 pupils compared with the total number of pupils enrolled in all physical sciences in this size of school.

Enrollment in Science 10 (8793 pupils) is almost equalled by the combined enrollments in Science 12 and Science 20 (8426 pupils).

Types of Rooms

Table V summarizes the types of rooms used by science teachers in high schools. The majority of teaching was done in two kinds of rooms: the physical science laboratory and the combined classroom and laboratory. There were more than twice as many of these two types as there were other types of science laboratories. The physical science laboratory was the dominant type.

Of particular interest was the fact that the least number of rooms (8.5 per cent) were of the modified classroom type with some laboratory facilities. There were only 6 rooms (11.5 per cent) of this type reported in the 1-59 category and the other categories had even fewer.

A large percentage (57.7 per cent) of physical science laboratories were reported in the 1-59 category. This type of laboratory room was also predominant in the 100-199 category. The combined classroom and laboratory was predominant in categories 60-99 and 200-499. Designated physics and chemistry laboratories became more frequent in occurrence in schools in the 200-499 category, and predominated in schools in the 500 or more category. Only a few (5) designated chemistry laboratories and no designated physics laboratories were found in schools with less than 100 students.

TABLE V

NUMBER AND TYPE OF SCIENCE ROOMS
BY SIZE OF SCHOOL

Type of Science Room	Size of School					
	1-59	60-99	100-199	200-499	500 or more	Total
Modified classroom with some laboratory facilities	6 11.5%	4 8.2%	5 10.2%	2 4.9%	2 6.2%	19 8.5%
Combined classroom and laboratory	12 23.1%	24 49.0%	16 32.6%	13 31.7%	6 18.7%	71 31.9%
Physical science laboratory	30 57.7%	20 40.8%	19 38.8%	9 22.0%	3 9.4%	81 36.3%
Designated chemistry laboratory	4 7.7%	1 2.0%	5 10.2%	11 26.8%	11 34.4%	32 14.3%
Designated physics laboratory	0 0.0%	0 0.0%	4 8.2%	6 14.6%	10 31.3%	20 9.0%
Total	52	49	49	41	32	223
Average number of science rooms per school	1.0	1.0	1.1	1.7	2.9	1.24

The sketches submitted with the questionnaire are instructive. As can be surmised, a great variety of floor plans of science rooms prevails. This variety makes it difficult to pick out typical or representative floor plans. However, an attempt was made to select plans as near to the typical as possible. These are shown in Figures 1 to 6 in Appendix C. Figures 1 and 2 show floor plans of science rooms in schools in the 1-59 category. One of these is a physical science laboratory and the other a combined classroom and laboratory.

Figures 2, 3 and 5 indicate that great variation is possible in planning a combined classroom and laboratory. Figure 4 illustrates a fairly simple type of plan, while Figure 6 has the unique feature of laboratory stations on a tiered floor. Most of the sketches submitted by teachers in small schools (category 1-59) revealed science laboratories in which there were wall cupboards with a wall bench, and one or more movable science benches in the middle of the room. There usually was one sink,or a drain which ran down the middle of the bench. Typically, the science laboratories were either long and narrow, or else they were square rooms with a floor area of three hundred to four hundred square feet. Several of these schools had a combined classroom and laboratory for teaching science.

Ancillary Science Facilities

In Table VI a comparison is made of other laboratory facilities such as water outlets, tables, bulletin boards, etc. The total number of each item is divided by the number of laboratory rooms in each size of

school category. For example, divide the number of fume hoods in the 1-59 category (43), by the number of rooms (52), to obtain the number of fume hoods per room, (0.83). Some items were so few in number that only the totals were given.

According to the figures of Table VI, the large schools were better equipped in types of fixtures per room than were the small schools. On the other hand, the small schools had more fire extinguishers and first aid kits per room than did the larger schools. There was no significant difference between the furnishings found in small schools compared with the large schools except in pupils' fixed tables which were greater in number in the large schools. Fixed tables were more numerous than movable ones. There were few movable demonstration tables in any schools. It appeared that almost every science room in schools in categories 60-99, 200-499, and 500 or more was provided with at least one fume hood. Chalk boards were more numerous than bulletin boards. Storage rooms were provided in one of every four science rooms in the 1-59 category, one of every five in the next two categories, and almost one of every two rooms in schools in the 500 or more category.

The floor covering most used throughout the schools was some type of tile, the vinyl or asbestos tiles being favored. In a few schools, some of which were building new science rooms, the flooring had been uncovered cement. A cement tile used in some schools was unsatisfactory because it tended to be slippery for walking and it caused too much breakage of equipment.

TABLE VI

NUMBER OF ANCILLARY LABORATORY FACILITIES
BY SIZE OF SCHOOL

Laboratory Facility	Size of School					
	1-59	60-99	100-199	200-499	500 or more	Total
Fixtures						
Water outlets, cold	198	247	261	256	255	1217
" " per room	3.81	5.03	5.32	6.24	7.97	5.46
Water outlets, hot	105	144	133	129	105	616
" " per room	2.02	2.94	2.71	3.15	3.28	2.76
Electrical outlets,AC	304	307	370	385	334	1700
" " per room	5.84	6.27	7.55	9.39	10.44	7.62
Electrical outlets,DC	12	3	20	39	38	112
Fume hoods	43	52	44	42	50	231
" " per room	0.83	1.06	0.90	1.02	1.56	1.03
Wall sink for general use of pupils	76	94	79	108	65	422
Wall sink per room	1.46	1.92	1.61	2.63	2.03	1.89
Laboratory stations	364	429	576	746	683	2798
" " per room	7.00	8.75	11.75	18.20	21.35	12.55
Gas outlets	342	310	503	664	704	2535
" " per room	6.57	6.33	10.26	16.18	22.00	11.33
Safety						
Fire extinguishers	66	58	68	42	15	249
" " per room	1.27	1.18	1.39	1.02	0.47	1.12
Number of exits	95	97	88	82	70	432
" " " per room	1.83	1.98	1.80	2.00	2.19	1.94
Shower baths	1	0	1	0	1	3
Eyewashers	12	8	3	17	2	42
First Aid Kits	41	36	37	22	16	122
" " " per room	0.79	0.73	0.76	0.54	0 .50	0.55

TABLE VI (Continued)

NUMBER OF ANCILLARY LABORATORY FACILITIES
BY SIZE OF SCHOOL

Laboratory Facility	Size of School					
	1-59	60-99	100-199	200-499	500 or more	Total
Furniture						
Teacher demonstration table	30	39	37	38	18	162
" " per room	0.58	0.80	0.76	0.93	0.56	0.72
Wall preparation table	29	27	18	25	22	121
" " per room	0.56	0.55	0.37	0.61	0.69	0.54
Pupil fixed table	114	152	215	210	268	957
" " per room	2.19	3.10	4.38	5.12	8.38	4.29
Pupil Movable table	8	23	22	51	1	105
" " per room	0.15	0.47	0.45	1.24	0.03	0.47
Demonstration table on wheels	10	22	3	3	1	39
" " per room	0.19	0.45	0.06	0.07	0.03	0.17
Equipment storage	249	288	215	245	141	1038
" per room	4.78	5.72	4.38	5.98	4.41	4.65
Bulletin boards	46	43	35	52	51	227
" " per room	0.88	0.88	0.71	1.27	1.59	1.02
Chalk boards	78	84	88	72	50	372
" " per room	1.50	1.71	1.79	1.75	1.56	1.67
Rooms						
Storage room	14	10	10	14	14	62
" " per room	0.27	0.20	0.20	0.34	0.44	0.28
Locked storage	15	23	17	15	8	78
" " per room	0.29	0.47	0.35	0.37	0.25	0.35
Darkroom	1	1	1	3	5	11
Office, consultation	0	0	2	1	2	5
Pupil project room	0	0	0	1	1	2
Project areas	1	0	1	1	0	3

Teacher Reaction to Laboratory Facilities

Table VII presents a summary of the teachers' reactions to the adequacy of the laboratory facilities in their schools. The teachers were asked to comment on the adequacy of science facilities. While less than one-half of the teachers reported that their laboratory facilities were not new, and the same number indicated that their facilities were inadequate, yet only slightly more than a quarter indicated that their facilities needed replacement. Teachers in Alberta schools in the 200-499 and the 500 or more categories felt that their science room furnishings were adequate.

Of the teachers reporting, 48 per cent thought that the furniture used was suitable. Teachers reported that pupils' stations were adequate in one-half the schools, but only one-third indicated that these were flexible arrangements. A few more schools used furniture which was made locally than furniture which was factory made.

While 45 per cent of the facilities were judged to be new by the teachers, and 48 per cent judged these to be adequate, yet there was individual storage for 46 per cent of the pupils. Little provision has been made in the total number of science rooms for libraries (7 per cent) and separate balance rooms (one per cent). In all 180 schools which answered the survey, there were only eleven darkrooms, five office rooms, two project rooms and two balance rooms.

Average Laboratory Space Per Pupil

The average number of square feet per pupil exclusive of storage for all physical science rooms in each size of school is shown in Table VIII. All schools were not included in these averages since dimensions

TABLE VII

NUMBER AND PER CENT OF SCIENCE TEACHERS ANSWERING "YES" TO ADEQUACY OF FACILITIES BY SIZE OF SCHOOL

Laboratory Facility	Size of School											
	1-59		60-99		100-199		200-499		500 or more		Total	
Rooms	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Individual storage for each pupil	29	56	24	49	26	53	13	32	10	31	102	46
Rooms can be darkened	12	23	17	35	20	41	11	27	9	28	69	31
Classroom library reading tables	4	8	4	8	3	6	5	12	0	0	16	7
Balance Room	0	0	0	0	0	0	1	2	1	3	2	1
Furniture												
Facilities are new	21	40	20	41	25	51	20	51	15	47	101	45
Facilities are adequate	19	37	17	35	24	49	22	54	24	75	106	48
Facilities need replacement	14	27	21	43	19	39	10	24	1	3	65	29
Storage space adequate	24	46	17	35	27	55	26	63	17	53	111	50
Pupils' stations adequate	16	31	21	43	30	61	27	66	19	59	113	51
Arrangement is flexible	19	37	16	33	20	41	15	37	12	37	82	40
Furniture made locally	19	37	25	51	34	69	17	41	13	41	108	48
Furniture made in factory	23	44	23	47	18	37	22	54	16	50	102	46
General Conditions												
Adequate heat	48	92	48	98	49	100	40	98	30	94	217	97
Adequate light	49	94	45	92	49	100	40	98	27	84	211	95
Adequate ventilation	39	75	33	67	32	65	27	66	26	81	157	70
Total number of laboratories	52		49		49		41		32		223	

of science rooms were not indicated in some cases, and the values in the last horizontal row indicate that some schools had areas substantially below the average.

TABLE VIII

AVERAGE NUMBER OF SQUARE FEET PER PUPIL IN PHYSICAL SCIENCE ROOMS

Averages	Size of School					
	1-59	60-99	100-199	200-499	500 or more	All schools
Average area in square feet	696	743	805	954	1251	850
Average number of pupils in classes	11.4	16.3	20.2	24.1	30.0	21.4
Average number of square feet per pupil	63	46	33	41	41	40
Square feet per pupil in selected schools	25	16	18	24	27	

Scheduled Use of the Physical Science Laboratory

To form some estimate of the use made of the physical science laboratory, teachers were asked to indicate the number of periods per school day, the use of time tables to avoid clashes in the use of science rooms, and the use of the laboratory rooms for extra-curricular science activities.

Table IX shows that the majority of the schools used the eight period school day five days of the week. This would give a laboratory period of approximately forty minutes.

TABLE IX

NUMBER OF PERIODS USED IN A SCHOOL DAY
BY SIZE OF SCHOOL

Number of Periods	Size of School					
	1-59	60-99	100-199	200-499	500 or more	Total
Nine period day	3	5				8
Eight period day	46	37	40	18	6	147
Seven period day	1	6	3	5	3	18
Six period day						0
Five period day			1			1
Block periods	2	1	1		2	6

Eighteen schools used the seven period day. Other schools had block periods, while some used a "week" which had a greater number of days than five. There was not much evidence of the longer science period which laboratory work needs. Some teachers indicated that when longer periods were needed they were taken.

In schools in which one teacher handled all the sciences which were taught, there was probably little need to schedule the use of the laboratory. But when there was more than one teacher involved, and there were few laboratories to accommodate all of the classes which needed to do laboratory work, then a timetable for the laboratory

became necessary. In most schools included in this survey the length of the laboratory period was the length of the regular class period. In large schools a science class was usually able to use the laboratory once a week. Figure 1 shows the percentage of schools using time-tables for regular scheduling of classes.

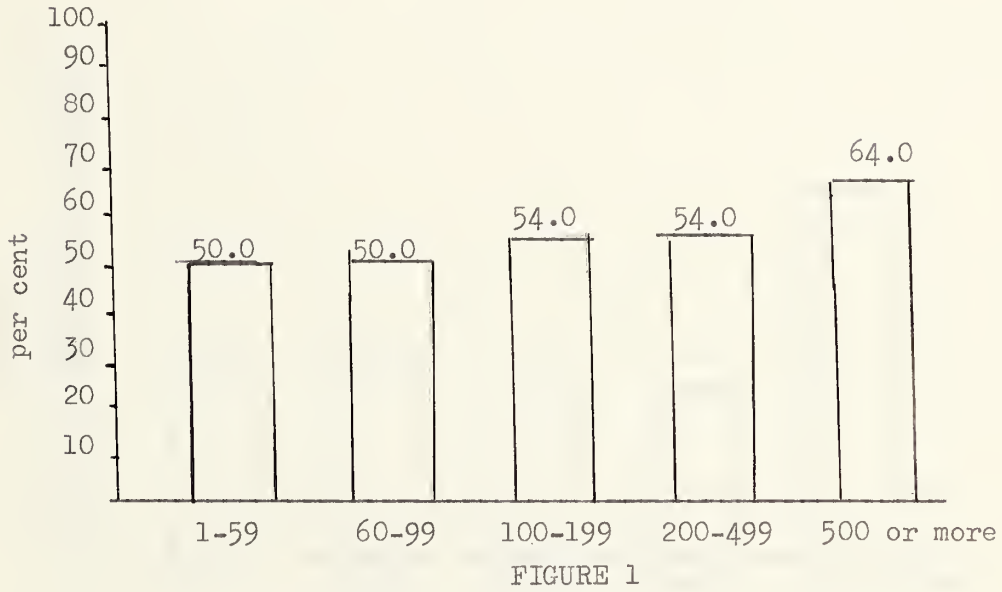

FIGURE 1

PERCENTAGE OF SCHOOLS USING LABORATORY TIME-TABLES BY SIZE OF SCHOOL

Figure 2 gives the results of questioning about the use of laboratories for extra-curricular science activities. The use of the laboratory for purposes other than regular laboratory work varied a great deal from school to school. In the smaller schools non-science activities were quite common. Science rooms

became home-rooms, typing rooms, study rooms, games rooms, or they served as a place to do work on the year book. In the larger schools extra-curricular science activities became more common; there was preparation for science fairs, extra experimental work or the completion of experiments.

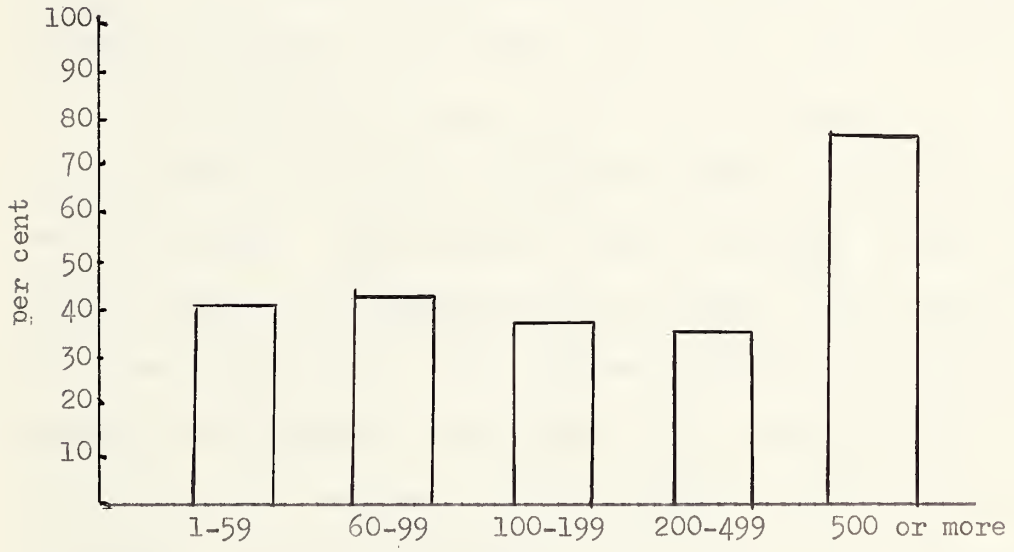

FIGURE 2

PERCENTAGE OF SCHOOLS USING LABORATORY ROOMS
FOR EXTRACURRICULAR SCIENCE PURPOSES
BY SIZE OF SCHOOL

CHAPTER IV

DISCUSSION OF SPACE FACILITIES FOR TEACHING SCIENCE

Introduction

Those rooms in the school building in which science is to be taught have always been expensive, and difficult areas of the school to plan. One reason has been the fact that while science itself and educational policies have changed, high school science teaching has been slow to respond to many of the newer developments, not only in course material, but also in the room in which the science courses are to be taught. There has also been a reluctance to spend money on science facilities commensurate with the needs of the science program, these needs being fixed space, permanent facilities and science materials and equipment. When many of the present laboratory rooms were built, there may have been recognition of the relation of science facilities to what was considered at the time to be an adequate educational program. Laboratories were often styled directly after college and university laboratories, not only in design, but in facilities and equipment as well. These rooms still persist in the designated physics and chemistry laboratories, in spite of the fact that they fail to reflect the best in educational practices for high schools. Many university classrooms were planned for passive learning activities, and their laboratories, for the training of young scientists in research activities.

Today, modern secondary school science teaching is more dynamic and has different objectives. Laboratory experience is considered to be an important avenue for learning concepts in science. In addition, many skills, attitudes and appreciations associated with the operation and development of science can be learned best, and in many instances, solely through genuine experimentation. To achieve, in some significant measure, the major objectives in science education, the science teacher and the students must have easy access to, and frequent use of, laboratory space.

Except in the largest schools, where highly specialized facilities may be used enough to justify their cost, science rooms should be designed for multipurpose use: that is, each science unit should be a combination classroom and laboratory which provides all needed facilities for the various activities involved in good instruction in science. A combination classroom-laboratory arranged and equipped for a wide variety of activities is usually preferred to the separate classroom and laboratory. Even in the large school where separate facilities are needed for each science course offered, it is usually desirable to plan a series of combination rooms each of which provides for the total range of activities. In such a room provision can be made for instruction, demonstration, discussion, pupil experimentation, individual guidance, research and study. Many variations in design of the combination classroom and laboratory are possible, of which Figures 2, 3, 5, 7, and 8, in Appendix C are illustrative.

Types of Science Rooms

Table V, p. 26 indicates that the physical science laboratory was most common in the schools represented in this survey. This type of room was most popular in the smaller schools. This, no doubt, could be explained by the economy obtained in providing a single laboratory for all the sciences which were taught in the school.

It is heartening to note that almost one-third of the science rooms represented in this survey were of the combined classroom and laboratory type. It might be surmised that newer trends in science rooms should appear in the larger schools. However, Table V indicates that this is not the case. In fact, the schools in the 500 or more category had the smallest proportion of this type of room and the highest proportion of designated physics and chemistry laboratories. The probable reason for this emphasis on designated physics and chemistry laboratories in the large schools is the priority given to laboratory work in the specialized sciences Chemistry 30 and Physics 30, and to the nature of the laboratory activities prescribed in these courses. These laboratory experiments are of the traditional "cook-book" type, and are certainly a reflection of the university influence mentioned above. If more laboratory experience were provided in Science 10, Science 12, and Science 20, the physical science laboratory and the combined classroom and laboratory would probably be more common in these schools.

It is instructive to compare the types and distribution of science rooms in the schools represented in this survey with data

reported in similar studies. In the report by Obourn and Koelsche[1] which consisted of a sample of 1,207 high schools, general science teachers were using rooms equipped for non-science courses and also combination classroom-laboratories (multipurpose rooms) with facilities for all sciences more frequently than any other type. They used separate recitation and laboratory rooms the least. Teachers in schools with enrollments below 500 were using multipurpose rooms to a greater extent than were those in schools with enrollments of 500 or more. However, even schools in this latter category were using multipurpose rooms more frequently than separate classrooms and laboratories.

Obourn and Koelsche reported that chemistry teachers were using multipurpose rooms and separate classrooms and laboratories more frequently than any other type of room. Chemistry and physics teachers in schools having enrollments below 500 were using multipurpose rooms to a greater extent than those having enrollments of 500 or more. Fewer chemistry and physics teachers were using rooms primarily equipped for non-science courses. A greater per cent of teachers in large schools were using combination classroom-laboratories for either a single science or two sciences than were teachers in small schools.

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[1]Ellsworth S. Obourn and Charles E. Koelsche, General Facilities and Equipment, U. S. Department of Health, Education and Welfare, Office of Education, Washington, 1960.

For non-specialized science courses, Obourn and Koelsche's[2] findings compare with those of this survey as follows:

(1) Classrooms equipped for non-science courses were more common in the schools covered by their studies than in the schools represented in this survey, since only 8.5 per cent of the science rooms were in this category (Table V).

(2) The combined classroom and laboratory was highly favored in the results of both studies.

(3) The separate classroom and laboratory was not dominant for the teaching of non-specialized courses in either study.

For the specialized courses, chemistry and physics, the following comparisons can be made:

(1) The combined classroom and laboratory was more common in the schools surveyed by Obourn and Koelsche than in the schools represented in this study.

(2) The separate classroom and laboratory appeared to be more common in the Alberta schools represented in this survey. Obourn and Koelsche did not define the physical science laboratory as a separate type of room but included it in the category, separate laboratory.

Science Room and Space Requirements

By using the following formula developed by the National Science Teachers Association[3], an estimate can be made of the number of rooms a

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[2] Ibid.

[3] National Science Teachers Association, School Facilities for Science Instruction, Washington: Department of the National Education Association, 1954, p. 19.

school may need for the physical sciences:

$$\text{Number of science rooms} = \frac{\text{student-periods}}{\text{average class size} \times \text{total number of periods per week}}$$

For example, 275 pupils enrolled in a physical science course meeting five periods per week would require 1.64 rooms, assuming a school day of 6 periods, with full utilization of the rooms every period, and an average class size of twenty-eight pupils. If the sum of all major science rooms needed is less than one, then a multipurpose classroom-laboratory should be considered. If the sum is nearly two, two multi-purpose laboratories, or an appropriate combination of rooms for maximum subject utilization should be sought.

Using the data supplied in the questionnaire, it was found that for schools which had up to two hundred pupils, the number of rooms needed, according to the formula, was usually not more than one. For example, using data from specific questionnaires, the following values were obtained:

School A:
1-59 category — Number of rooms $= \frac{46 \times 5}{11 \times 40} = 0.52$

School B:
60-99 category — Number of rooms $= \frac{83 \times 5}{21 \times 40} = 0.49$

School C
100-199 category — Number of rooms $= \frac{162 \times 5}{27 \times 40} = 0.75$

According to Table V, p. 26, the average numbers of laboratories for the first three categories were 1.0, 1.0, and 1.1 respectively. It would appear that there were a sufficient number of science rooms in the

schools in these categories.

For the schools represented in the survey with more than 200 pupils, 2 rooms were found to be enough according to the above formula. Yet according to Table V, the average number of science rooms in this category was 1.7. This indicates that some schools were under the minimum requirements. For example, two schools selected from the survey should have had the following number of science rooms:

School D: 200-499 category — Number of rooms = $\frac{300 \times 5}{26 \times 40} = 1.4$

School E: 500 or more category — Number of rooms = $\frac{260 \times 5}{21 \times 40} = 1.5$

In actual fact, School E met the requirements with two rooms, while School D with its single room did not.

For schools with enrollments above 500 pupils, the formula shows that three or four rooms would be sufficient. Table V shows the average number to be 2.9. Out of eleven schools in this 500 or more category, six schools had only two science laboratories, two had three, one had four and two had five. In these schools there were a total of thirty-two science rooms, when at least forty were required according to the formula. This discrepancy between the requirement and provision is borne out by School F in the survey for which the formula applies as follows:

School F 500 or more category — Number of rooms = $\frac{1369 \times 5}{32 \times 35} = 6.1$

Yet this school had only two designated science rooms. This meant that in a seven period day, five day week, a very tight schedule had to be followed. Out of a total of seventy available laboratory periods per week, sixty-two were used by fourteen teachers. This was less than five periods per week per teacher, indicating that some science classes did not work in the laboratory during the week. A minimum of four physical science rooms seemed to be needed. Two other schools with high enrollments had two physical science laboratories each but needed at least two more laboratories each to handle enrollments of 1,170 in both schools.

The apparent inadequacy of space for teaching science in some schools in Alberta is further underlined by the following evidence:

(1) Table VIII, p. 33 indicates the average space per pupil provided in the schools represented in the survey. The number of square feet per pupil was above the thirty-five square feet usually considered to be a minimum except in the 100-199 category. However, all schools did not meet this recommended minimum.

(2) The size of the science class has to be conceived realistically if profitable individualized laboratory experiences are to be provided. Research evidence on this matter is not available. Estimates of optimum size of laboratory classes run from fewer than twenty as high as thirty pupils. It is certain however that any reduction in class size would necessitate an increase in the number of science rooms in a school.

CHAPTER V

DISCUSSION OF ANCILLARY SCIENCE FACILITIES

Even though laboratory space in a school may be adequate, it is not of much use for science teaching if it is not well-equipped with storage space, furniture, and services such as water, gas, electricity, and heat. It also needs proper ventilation, lighting, acoustical treatment and floor covering. In addition, special consideration must be given to protection from fire and other hazards resulting from the use of potentially explosive or poisonous materials, or from electrical equipment.

In discussing these facilities, use will be made of recommendations taken from Facilities and Equipment for Science and Mathematics.[1] Unfortunately, this publication does not offer recommendations on ancillary facilities on a per pupil basis so that an assessment could be made of the adequacy of these facilities in the schools of Alberta.

Furniture

Table X summarizes the recommendations given in this publication on furnishings. The data reported on furniture in Table VI, pp. 29-30

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[1] W. Edgar Martin, Facilities and Equipment for Science and Mathematics, Misc. 34, U.S. Department of Health, Education, and Welfare, Office of Education, Washington, D.C., 1960.

TABLE X

SCIENCE ROOM FURNISHINGS

Furniture	Recommendations
Student seating	(a) Tablet arm chairs (b) Movable tables and chairs for both experimental work and lectures
Laboratory tables or stations	(a) Fixed laboratory stations, with utilities, located in the middle of the room. (cf. Figure 4, Appendix C) (b) Fixed stations, with utilities, along the wall. (cf. Figure 7, Appendix C) (c) Fixed peripheral stations, with utilities, perpendicular to the wall. (cf. Figure 2, Appendix C)
Wall storage	All available wall space for shelves or cupboards. (cf. Figure 2, Appendix C)
Demonstration desks	(a) Size: 2'6" x 8'0" x 36" with utilities (b) Movable demonstration table
Fume hoods	One or more large fume hoods with blower ventilation
Bulletin board	Maximum in science rooms
Chalkboard	20 lineal feet minimum; 42 in. high. At least 16 feet on front wall.
Science library	Open shelves for books Table and chairs Racks for magazines

seem to meet to a satisfactory degree the recommendations outlined in Table X. Unfortunately, no information was solicited through the questionnaire on the nature of student seating. Apart from the modified classrooms used for teaching of science, the science rooms represented in this study were provided with one or more types of laboratory stations recommended in Table X. Provision of wall storage, demonstration desks, fume hoods, bulletin boards, and chalkboards appeared to be adequate in most science rooms. Few schools reported having library corners in the science rooms, (cf. Table VII).

In Obourn and Koelsche's survey[2], 77 per cent of the schools were equipped with demonstration tables. Demonstration tables on wheels were scarce in the smaller schools, but the larger schools were better equipped in this regard. Only 20 per cent of the schools in their survey had fume hoods. They also reported adequacy in the provision of chalkboards and bulletin boards. Equipment storage remained at about the same level for each category of school. They reported library shelves in 46.8 per cent of the science rooms and library areas with tables and chairs in 10.3 per cent. Hence, in most respects, their findings are similar to those of this survey for Alberta schools.

A comparison of the average number of laboratory stations, Table VI, pp. 29-30, with the average class size, Table IV, p. 24, is

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[2]Ellsworth S. Obourn and Charles F. Koelsche, Science and Mathematics in Public High Schools, Part 1, General Facilities and Equipment, U.S. Department of Health, Education and Welfare, 1958, p. 10.

instructive. The ratio of pupils to stations ranges from a low of 1.4 for schools in category 500 or more to a high of 1.9 for schools in the category 60-99. This difference is probably not significant in view of the common practice of pairing students for laboratory experimental work. On the average, the number of laboratory stations in the science room appeared to be adequate in the schools represented in this survey, provided that grouping for laboratory work was assumed to be satisfactory. However, this comparison does not necessarily tell the whole story. It has already been pointed out that most of the large schools had an insufficient number of science rooms, and that use of laboratories was possible only if a strict schedule was followed. Both the tight scheduling and lack of sufficient number of rooms violates the principle of easy accessibility to laboratory facilities for teaching science.

It is difficult to assess the reliability of the reaction of science teachers (cf. Table VII) towards their science facilities since no criteria were indicated in the questionnaire. It is significant, however, that only half of the teachers felt that furnishings and the number of laboratory stations were adequate. Furthermore slightly under one-third of the teachers indicated that furnishings needed replacement. The apparent conclusion is that many schools were inadequately provided for teaching science. If this can be said of science facilities for teaching the present courses in high school physical science, then the inadequacy would obviously become more serious for teaching courses which place greater emphasis on laboratory work.

Utilities and Services

Table XI summarizes the recommendations for utilities and services given in Facilities and Equipment for Science and Mathematics.[3] The utilities and services provided in the science rooms represented in this survey of Alberta schools again conformed qualitatively with the recommendations (cf. Tables VI and VII with Table XI). It is significant that all the schools had natural gas. The vast majority of the science teachers indicated that heating, lighting and ventilation were adequate. Of these three services, ventilation was considered the least satisfactory. No information was solicited about special ventilation for the science room; that is, ventilation separate from that provided by the fume hood. No information was obtained in the survey on the design and materials in waste-lines, and on wall and ceiling finishing. Some schools reported uncovered cement finishing on the floor.

An estimate can be made of the adequacy of utilities in the science rooms used for laboratory work by comparing the average number of outlets of each type per room with the average number of stations per room (cf. Table VI). Each laboratory station had one gas outlet. Cold water and AC current outlets numbered about one per two stations. Hot water outlets were less common, and DC current outlets were scarce. Thus it would appear that apart from hot water, the provision of essential utilities is minimally adequate for laboratory work in

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[3]Facilities and Equipment for Science and Mathematics, loc. cit.

relation to the number of science stations provided.

TABLE XI

UTILITIES AND SERVICES

Utilities and Services	Recommendations
Water	Hot and cold water at work stations. Sink and waste-lines to be of acid-resisting material
Electricity	Master switch 110 volt AC with breakers on teacher demonstration desk, at pupil work stations, and in storage rooms and preparation rooms. DC recommended but not essential.
Gas	Master valve. Outlets to be provided on demonstration desk, and pupil stations. Propane or butane gas in schools not provided with natural gas.
Heat	68 deg. F. design operative temp.
Ventilation	Special ventilation for poisonous or objectionable odors - fume hoods. 10 cu. ft. per minute per person fresh air.
Lighting	50 ft.-c. recommended average; separate circuits for light control
Floor coverings	Vinyl asbestos or vinyl plastic tile.
Walls and ceilings	Acoustic tile; fireproof and capable of being cleaned or painted.

Ancillary Rooms

Table VI indicates that fewer than half of the science rooms had an adjacent storage room. Certainly every science room used for laboratory work should have a storage room, or there should be at least one storage room for two adjacent science rooms. Only schools in category 500 or more come close to the latter ratio. A large amount of equipment and materials is needed for teaching science. It is true that wall and cupboard space in the science room can accommodate some of the supplies. However, only half of the teachers felt that storage space in the science room was adequate (cf. Table VII). In addition, a special room should be provided for preparations.

Types of rooms other than storage rooms were few. There was inadequacy here. In all 180 schools which responded te the survey, there were only eleven darkrooms, five office rooms, two project rooms and two balance rooms. Only three schools had areas in which pupils could leave work undisturbed for future experimentation.

Safety

Safety seemed to have been recognized as an important factor in the planning of the science rooms represented in this survey. There was at least one fire extinguisher in each science room, except in schools in category 500 or more. Most rooms had two exits. However, for accidents with acids, there were few showers in the science rooms, the science teacher probably relying on the water outlets. The number of eyewashers reported was probably not significant since these were

probably mistaken by teachers for eye cups. The eyewashers are fountains especially built to bathe the eyes in case of accident. There was a large number of science rooms without first aid kits. More safety measures should be provided. Each science room should have a first aid kit, two fire extinguishers, two exits, a shower and an eyewasher.

CHAPTER VI

FLEXIBILITY IN SCIENCE FACILITIES

In the literature on facilities for teaching senior science frequent mention is made on the need for planning these facilities for flexible use. One obvious advantage is that a science room may be used for a variety of teaching activities in the different sciences. Thurber and Collette[1] have this to say about flexibility of science facilities:

> The ideal classroom has an area in which the pupils meet for such activities as recitations and demonstrations, and other areas to which they are directed for experiments and project work. All this work space is flexible; seats may be reorganized for general discussions and for small group plannings and large areas of floor space may be cleared for special activities.

An additional argument for planning science facilities for maximum flexibility is that science programs undergo frequent revision, both in content and in teaching methodology; as in for example, the new studies in physics and chemistry referred to in Chapter I. These unforeseen demands made by new programs can obviously be best met by science facilities designed for flexible use.

Flexibility can be obtained in the following ways:

(1) Type of science room: It has already been suggested that

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[1]Walter A. Thurber and Alfred T. Collette, Teaching Science in Today's Secondary Schools, Allyn and Bacon, New York, 1959, pp. 581-82.

the combination classroom is the most desirable type since it allows for freedom of movement and rearrangement of furnishings as well as giving easy accessibility to equipment and supplies. It has already been suggested in Chapter IV, p. 39, that this type of room should predominate in the schools of Alberta, whereas in actual fact, it does not.

(2) Sufficient floor space in the science room: In Idaho[2] minimum floor areas recommended exclusive of storage rooms are as follows:

Separate laboratory: chemistry, 960 square feet.

Physical science laboratory: 2 or more sciences, 1056 square feet.

Combination classroom and laboratory: 1400-1600 square feet.

Although recommended areas are valuable in designing science rooms, it must be recognized that size of science rooms must be seen in relation to class size. Table VIII, p. 33 indicates that most science rooms represented in this survey fall below the recommended areas suggested above, but that the ratio of floor space to class size is adequate in all categories except in schools in category 100-199. Apart from the apparent adequacy of floor space, the sketches submitted with the questionnaire seemed to indicate that the furniture in many science rooms was too crowded, and that long benches for experimental work curtailed ease of movement.

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[2]W. Edgar Martin, Facilities and Equipment for Science and Mathematics, Misc. 34, U.S. Department of Health, Education and Welfare, Office of Education, Washington, D.C., 1960, p. 23.

(3) Proximity of science rooms to one another: Locating science rooms close to one another facilitates the shifting of classes, supplies, and furniture. It is suggested in the literature that larger schools should have a science wing or even a separate science building. Unfortunately no information was obtained in this survey in regard to location of science rooms to one another and in the school plant.

(4) Ancillary rooms: Storage, preparation and project rooms enable individual (teacher or pupil) and group activities to go on when the science room is in use by other teachers or classes. Furthermore, separate areas are required by teachers and pupils for preparing, assembling and storing materials and equipment. It has already been indicated in Chapter V that the vast majority of the Alberta schools did not make adequate provision for these types of rooms.

(5) Design, location and attachment of furniture: Of all the science room furnishings, the student laboratory tables present the most difficulty in regard to design and location. Thurber and Collette[3] describe the nature of the problem in the following words:

> The largest space investment is likely to be the student laboratory tables, and these units are also the most difficult to locate properly. These tables are inflexible by nature; their position cannot be varied, their surfaces being broken up by utility services and sinks provide little clear space, and their surfaces cannot be used for construction or other rough work.

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[3]Thurber and Collette, loc. cit.

The difficulty may be partially solved in the following ways: first, not all stations need to have utility outlets; that is, a science room should be provided with some movable tables. Table VI, pp. 29-30 indicates that fixed tables were much more common than movable tables in the science rooms represented in this survey. It is no wonder that 60 per cent of the teachers reported that arrangement of furniture in their science rooms was not flexible, (cf. Table VII, p. 32). Second, utilities and sinks should be separated from the laboratory bench and should be contained in a separate service strip. The laboratory bench with storage drawers and cupboards should be of the movable type. Third, long laboratory benches should be avoided so as to facilitate traffic in the laboratory area and to enable moving benches from one part of the room to another.

CHAPTER VII

SUMMARY AND RECOMMENDATIONS

Introduction

The findings in this study were based upon the data supplied in 1962 by science teachers in 180 high schools in Alberta. It is to be hoped that the science facilities in these schools were fairly representative of facilities in all high schools in the province at that time. Many of the conclusions were based on averages for all the science rooms.

The responses to the questionnaire (Appendix A) provided significant information from which valid conclusions could be derived. Through oversight, some items were not included in the questionnaire, for example, student seating, waste disposal, and proximity of science rooms to one another. Consequently, this study is incomplete in several minor respects.

Summary

(1) Of the total pupils enrolled in the schools represented in this survey, a high percentage (84.7 per cent) were enrolled in the physical sciences.

(2) The four course program consisting of Science 10, Science 20, Chemistry 30 and Physics 30, and the full five course program, in which Science 12 was added to the above four courses, were offered in more than two-thirds of the high schools.

(3) The dominant types of science rooms were the physical science laboratory and the combined classroom and laboratory. The designated chemistry and physics laboratories were found most frequently in the largest schools. In the light of the advocacy of the combined classroom and laboratory it can be concluded that this type of room is not as common as it should be.

Average floor area in the science rooms appeared to be adequate in relation to average class size. The number of science rooms per school appeared to be adequate in all categories except in category 500 or more. Many science rooms were outdated and required renovating and refurnishing.

(4) Provision of storage rooms appeared to be minimally adequate in the largest schools and virtually non-existent in the smallest schools. Other types of ancillary rooms such as project rooms, and balance rooms, were few in number.

(5) Fixed laboratory tables were reported much more frequently than the movable type. The number of laboratory stations provided appeared to be adequate in most schools for pupils working in the laboratory in groups of two or more. Other types of furnishings such as wall storage, demonstration desks and fume hoods appeared to be adequately provided.

(6) The provision of utilities and services appeared to be minimally adequate in respect to the number of laboratory stations.

(7) Safety provisions were found to be inadequate.

(8) A comparison of the findings of this study with those of Obourn and Koelsche[1] indicated little difference in the science facilities provided in the science rooms in Alberta and in the United States. The major difference was with respect to the type of science room most common in the schools.

(9) The science rooms represented in the Alberta survey appeared to lack the flexibility desired in science facilities. To achieve greater flexibility, a higher proportion of combined classroom-laboratories and ancillary rooms would have to be provided, and movable furnishings installed.

(10) An assessment of the adequacy of science facilities in the schools represented in this survey is difficult to make. This assessment would have to be made both for the teaching of the present physical science and for the future programs which will probably place greater emphasis on laboratory work. Valuable information is given in the literature on science facilities, but little research evidence is available on which to make even qualitative assessments of adequacy either of current or future programs.

An assessment of adequacy would also require a knowledge of the trends in pupil enrollment and the rate of building of new schools. This kind of comparison is beyond the scope of the present study.

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[1]Ellsworth S. Obourn and Charles L. Koelsche, Science and Mathematics in Public High Schools, Part 1, General Facilities and Equipment, U.S. Department of Health, Education, and Welfare, Office of Education, Washington, D.C., 1960.

Recommendations

(1) The information produced by research on science facilities is a requisite to intelligent school planning. Such research could well be one of the fields of investigation for the secondary science education staff at the Faculty of Education of the University of Alberta. The Science Council of the Alberta Teachers' Association, the Department of Education and the major educational systems in the province should concern themselves with a study of this problem on a continuing basis.

(2) More direction in the planning of science facilities should come from the Department of Education. The Department should sponsor a cooperative planning project to develop a code establishing both the minimum requirements and the optimum requirements for science facilities. This code should incorporate the best thinking of many qualified persons such as science teachers, school administrators, specialists in the teaching of science, school building consultants, and architects. The Department of Education should then regulate construction of new facilities within this code. The code should be re-examined periodically.

(3) Science rooms in current use which are not to established specification should be remodelled and refurnished.

(4) The problem of an insufficient number of science rooms in the large schools should be solved by converting adjacent classrooms into science rooms, or by building a new science wing. Converted rooms should be fully equipped with utilities and science furnishings.

(5) The reports of high school superintendents should include more information on laboratory facilities and on their value and use. The accumulation of such information would provide valuable direction to planners for science facilities and would indicate trends in improvement of these facilities.

(6) The problem of adequacy of laboratory facilities in Alberta High Schools requires further study.

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APPENDIX A.

QUESTIONNAIRE

11454 - 79 Ave.,
Edmonton, Alberta,
May 18, 1962.

Dear

It would seem possible that with new courses in physical science about to be introduced into Alberta schools, more emphasis will be placed on experimental work in the laboratory. If this is so, then investigation of the adequacies of the physical science laboratories would be of great help.

This questionnaire has been sent out for the following reasons. First, it will form the basis for my master's thesis on the adequacy of space facilities in the physical sciences. By space facilities are meant rooms, furnishings, services, permanent equipment, supplementary facilities such as storage rooms, all of which provide an adequate setting for scientific teaching and learning. Apparatus and scientific materials will not be considered here. They will vary with the curricula and are quite readily changed when necessary. Second, it could serve as a basis for improvements which could be made in existing laboratories. Because of the nature of the facilities required, science courses have been one of the more costly items of the school program, since these facilities have generally not been suitable for any other purpose.

The information collected will be strictly confidential. A self-addressed envelope is enclosed for the completed questionnaire. I hope that this will not take too much of your time and of your science teachers' time when there are so many other forms to be filled out. Thank you for your cooperation.

Yours very truly,

Ole A. Olson, Science teacher
Strathcona Composite High School

INSTRUCTIONS FOR FILLING OUT THE QUESTIONNAIRE

Page 1. To be completed by the principal.

Pages 2 - 5. To be completed by the science coordinator, teacher or teachers of physical sciences.

Page 3. In many schools only Unit 1 of one column may need filling. If the designations do not seem to fit your science room, there may be another description which you would prefer.

Page 5. This page was added so that the diagram would reinforce the details already given.

QUESTIONNAIRE ON LABORATORY SPACE FACILITIES IN THE PHYSICAL SCIENCES FOR SECONDARY HIGH SCHOOLS

GENERAL INFORMATION

1. Name of the school _____

2. City, town, village _____

3. What is the total high school enrollment in your school? _____

4. What is the enrollment in the physical science classes?

Course	Number of classes, or sections	Total number of pupils
Science 10		
Science 12		
Science 20		
Chemistry 30		
Physics 30		

5. a. On what period system is your high school day based? 8 period day, 8 day week, block periods, etc.

_____

b. Are laboratory periods regularly scheduled according to a time table? _____

c. Are pupils allowed to use the laboratory for purposes other than for regular class experimentation?

Specify _____

_____

2

DATA ON LABORATORY SPACE FACILITIES

TABLE I

To the science coordinator, or teacher

1. Five possible types of science facilities are given. Please fill in data which may be applicable to the particular type(s) in your school.
2. Give the approximate size of your room(s) in feet.
3. If there is additional information, it may be added in the space below.

Facility	Modified classroom with some laboratory facilities		Combined Classroom and laboratory		Physical Science laboratory		Designated Physics laboratory		Designated Chemistry laboratory	
Number of units of each										
Number of classes and students using each unit in:	No. of Classes.	No. of Students	No. of Classes.	No. of Students	No. of Classes.	No. of Students	No. of Classes.	No. of Students.	No. of Classes	No. of Students.
Grade IX										
Science 10										
Science 12										
Science 20										
Chemistry 30										
Physics 30										
Biological Sciences										
SIZE	L	W	L	W	L	W	L	W	L	W
Length X Width	X		X		X		X		X	

TABLE II

Please indicate the total number of each of the following facilities in the laboratory rooms indicated. Unit 1 or Unit 2 refers to the fact that there may be more than one of these rooms available.

Facility	Modified Classroom with some facilities		Combined Classroom and Laboratory		Physical Science Laboratory		Designated Physics Laboratory		Designated Chemistry Laboratory	
	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2
FIXTURES										
Water outlets-cold										
Water outlets-hot										
Electrical outlet AO										
Electrical outlet DO										
Fume hoods										
Wall sink for general use of students										
Laboratory stations										
Gas outlets										
FURNITURE										
Teacher demonstration table										
Wall preparation table										
Pupils' fixed experimentation tables										
Pupils' moveable experimentation tables										
Demonstration table on wheels										
Equipment storage cupboards										
Bulletin boards										
Chalkboards										

TABLE II
(continued)

Please indicate the total number of each of the following facilities in the laboratory rooms indicated. Unit 1 or Unit 2 refers to the fact that there may be more than one of these rooms available.

Facility	Modified Classroom with some facilities		Combined Classroom and Laboratory		Physical Science Laboratory		Designated Physics Laboratory		Designated Chemistry Laboratory	
	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2
ROOMS										
Storage room for chemicals, equipment.										
Locked storage chemicals equipment										
Darkroom for photography										
Office room for consultations etc.										
Pupils' project room										
Project areas for individuals										

TABLE III

Please answer yes or no in the spaces below, if the facilities stated are found in the laboratory rooms indicated.

Facility	Modified Classroom with some laboratory facilities		Combined Classroom and laboratory		Physical Science Laboratory		Designated Physics Laboratory		Designated Chemistry Laboratory	
	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2
ROOMS										
Individual storage for each pupil										
Rooms have classroom libraries and reading tables										
Rooms can be darkened for slide and movie projection.										
Balance room										
FURNITURE										
Facilities are new										
Facilities are adequate										
Facilities need replacement.										
Storage space for equipment is adequate										
Pupils' stations are adequate for satisfactory experimental work.										
Furniture and furnishings are arranged so as to give maximum flexibility										

TABLE III
(continued)

Please answer yes or no in the spaces below, if the facilities stated are found in the laboratory rooms indicated.

Facility	Modified Classroom with some laboratory facilities		Combined Classroom and laboratory		Physical Science Laboratory		Designated Physics Laboratory		Designated Chemistry Laboratory	
	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2
FURNITURE										
Furniture made locally										
Furniture factory made										
GENERAL CONDITIONS										
Adequate heat										
Adequate light										
Adequate ventilation										
Floor covering (specify)										
SAFETY (answer with numbers as on preceding page 3)										
Fire extinguishers										
Number of exits										
Shower bath for accidents with acid										
Eyewashers										
First Aid Kit										

SKETCH OF LABORATORY

Would you please make a quick sketch of your physical science laboratory room(s).

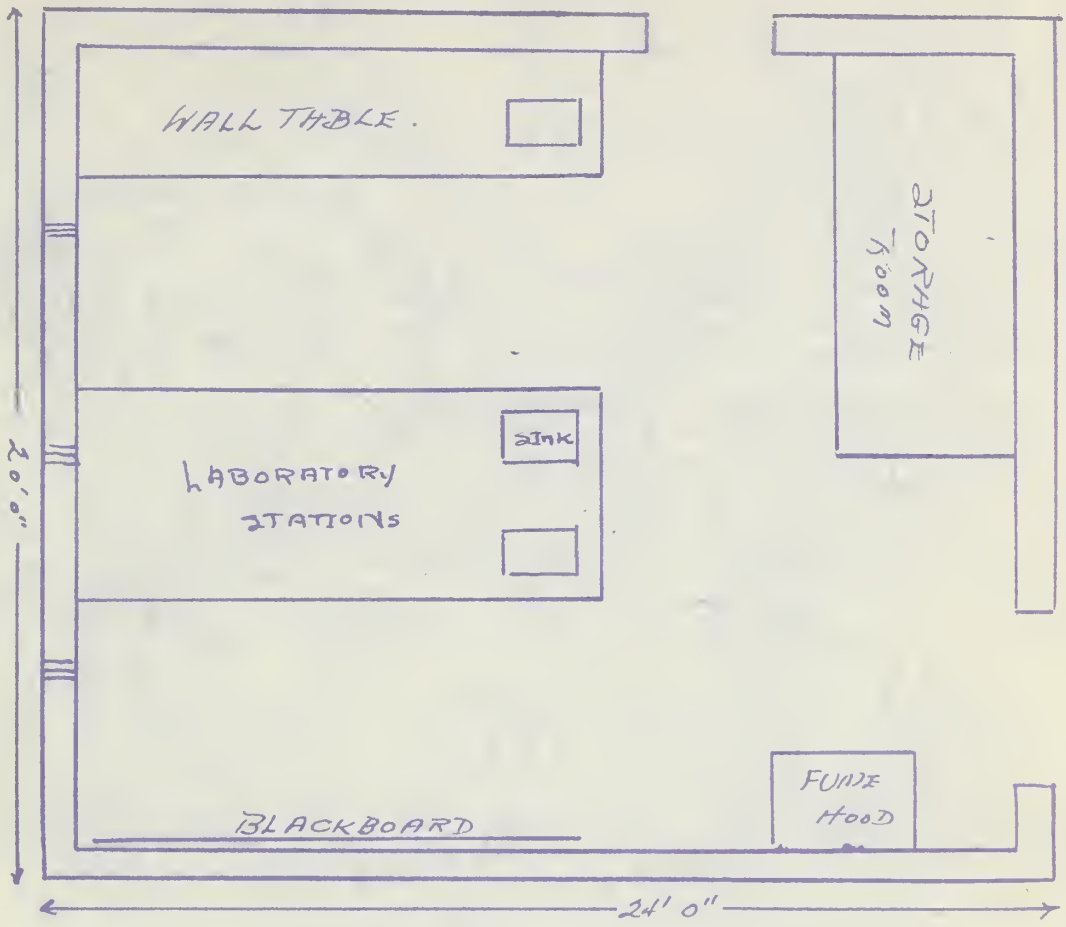
APPENDIX B

MAP OF ALBERTA SHOWING LOCATION OF SCHOOLS RETURNING QUESTIONNAIRES

Map of Alberta showing location of schools returning questionnaires

APPENDIX C

FLOOR PLANS OF SELECTED SCIENCE ROOMS REPRESENTED IN THIS SURVEY AND RECOMMENDED FLOOR PLANS OF COMBINED CLASSROOM LABORATORIES

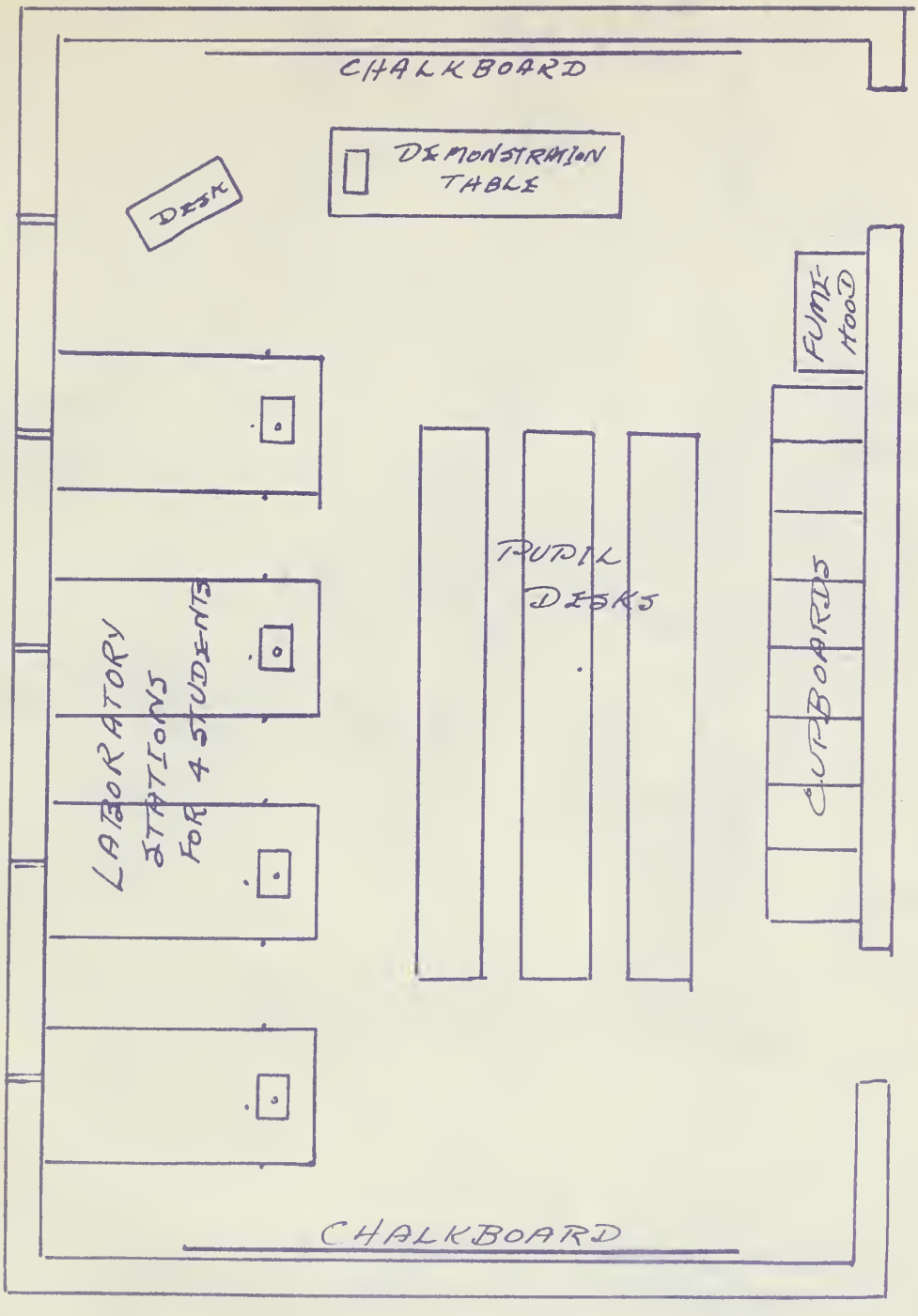


Physical Science Laboratory

School Size: 1-59

Number of pupils: 36

FIGURE I

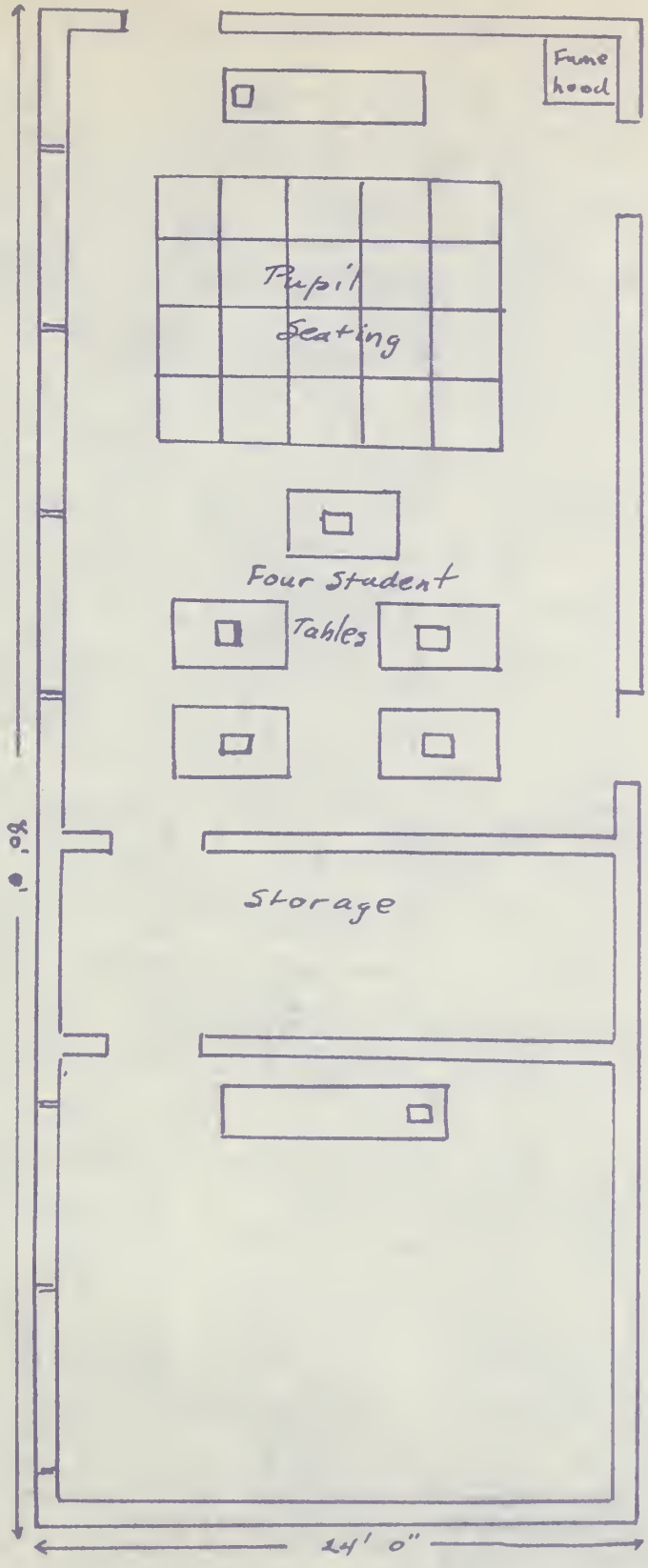


COMBINED CLASSROOM AND LABORATORY

SCHOOL SIZE: 1-59

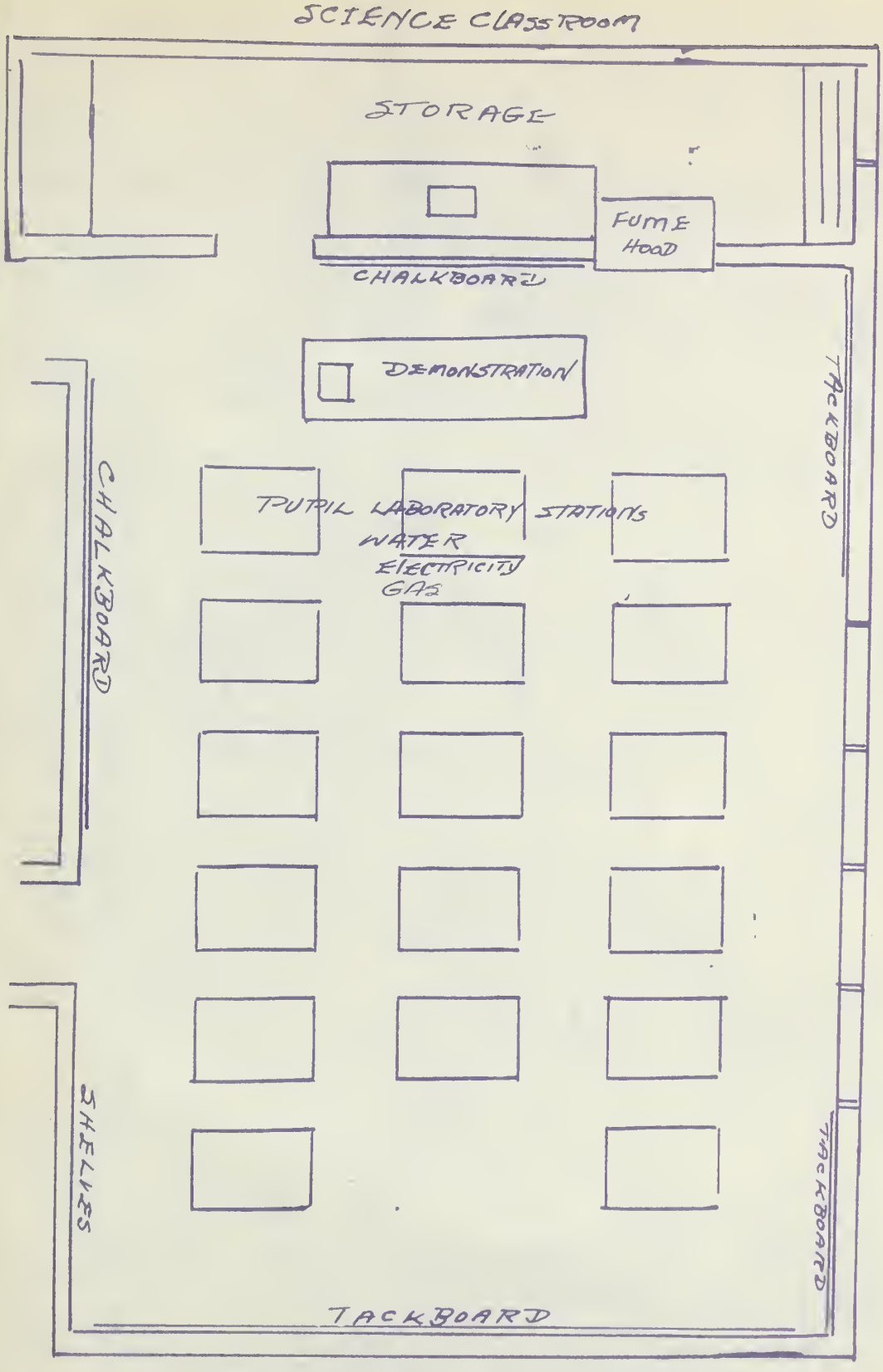
NUMBER OF PUPILS: 35

FIGURE 2



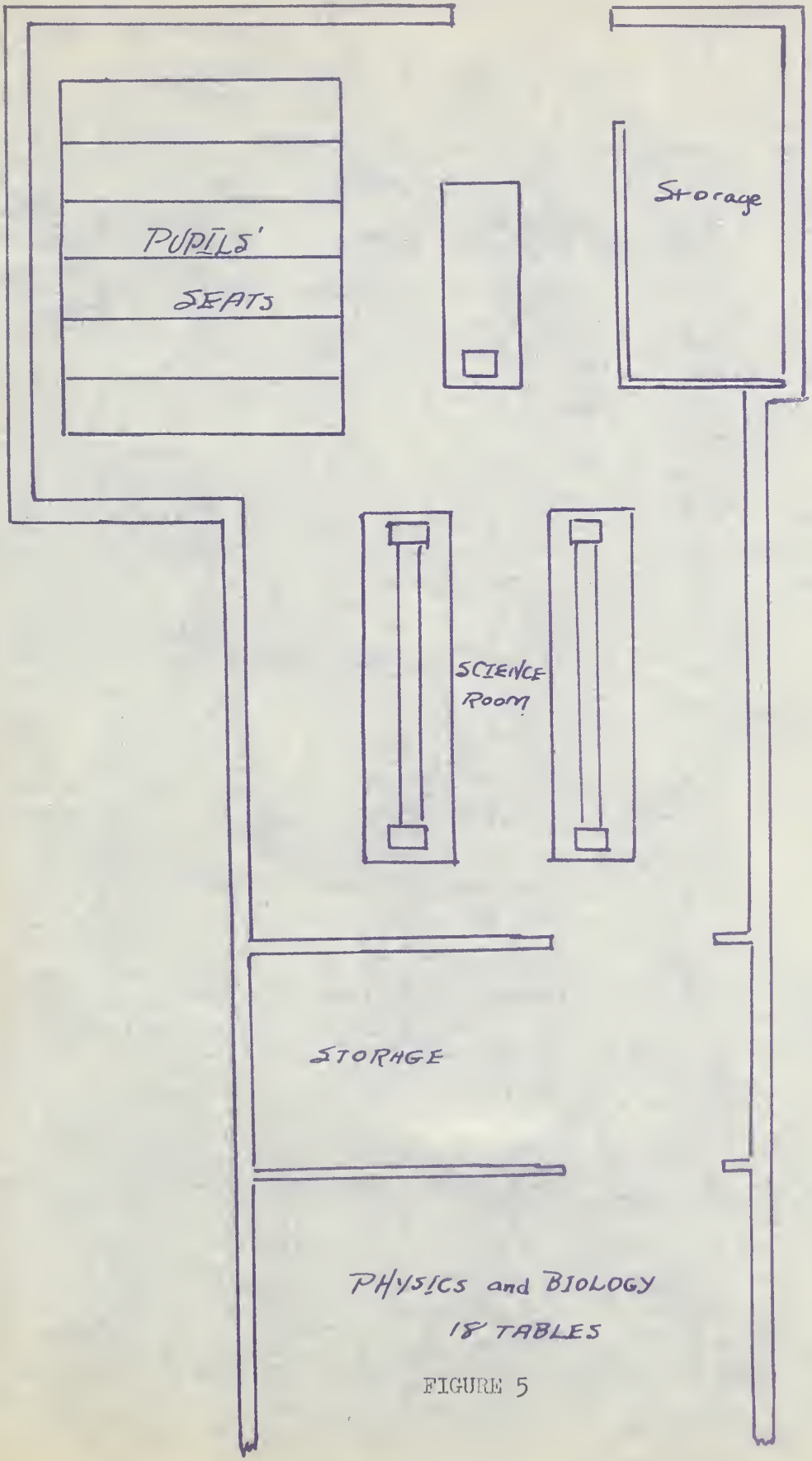
New Combined Classroom and Laboratory with adjoining storage and classroom
Size of school: 60-99

FIGURE 3



NEW PHYSICAL SCIENCE LABORATORY
SIZE OF SCHOOL: 100 - 199

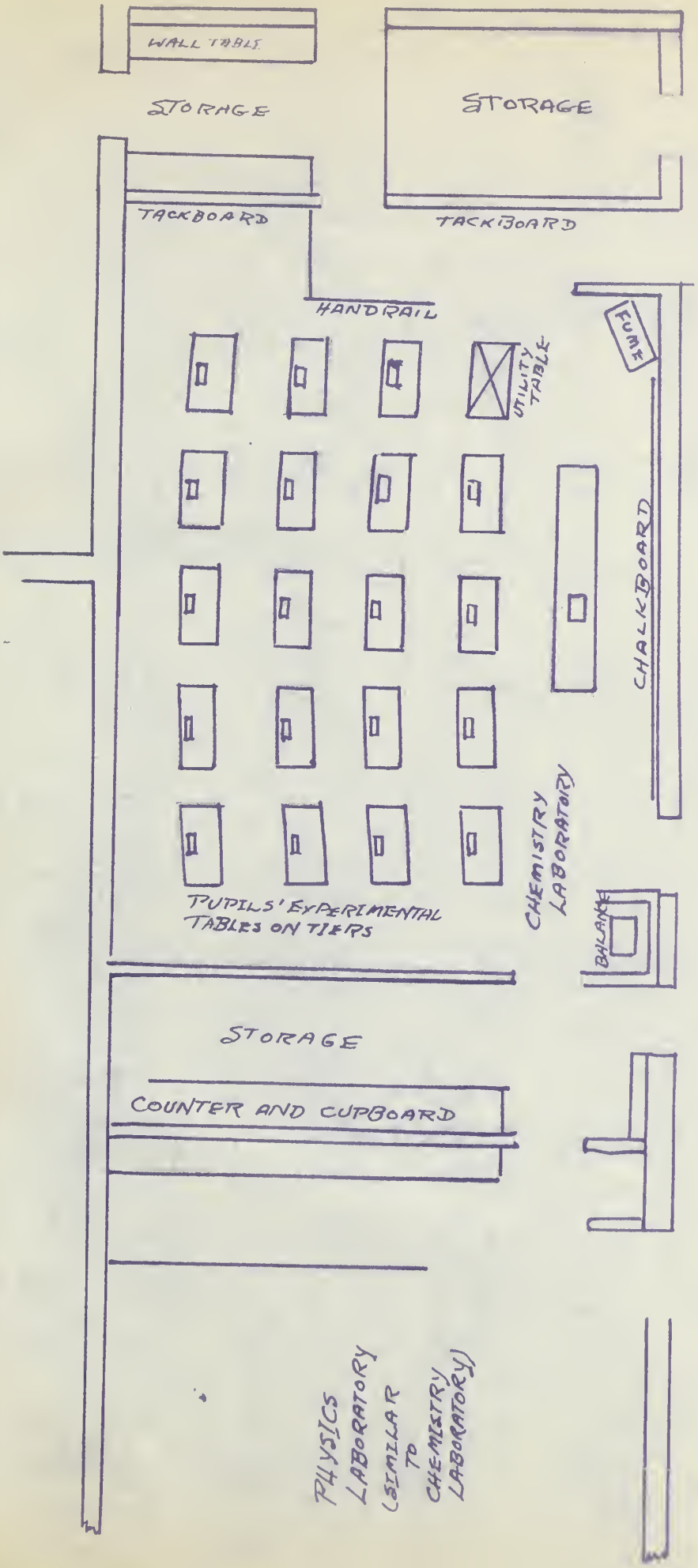
FIGURE 4



NEW COMBINED
CLASSROOM + LABORATORY

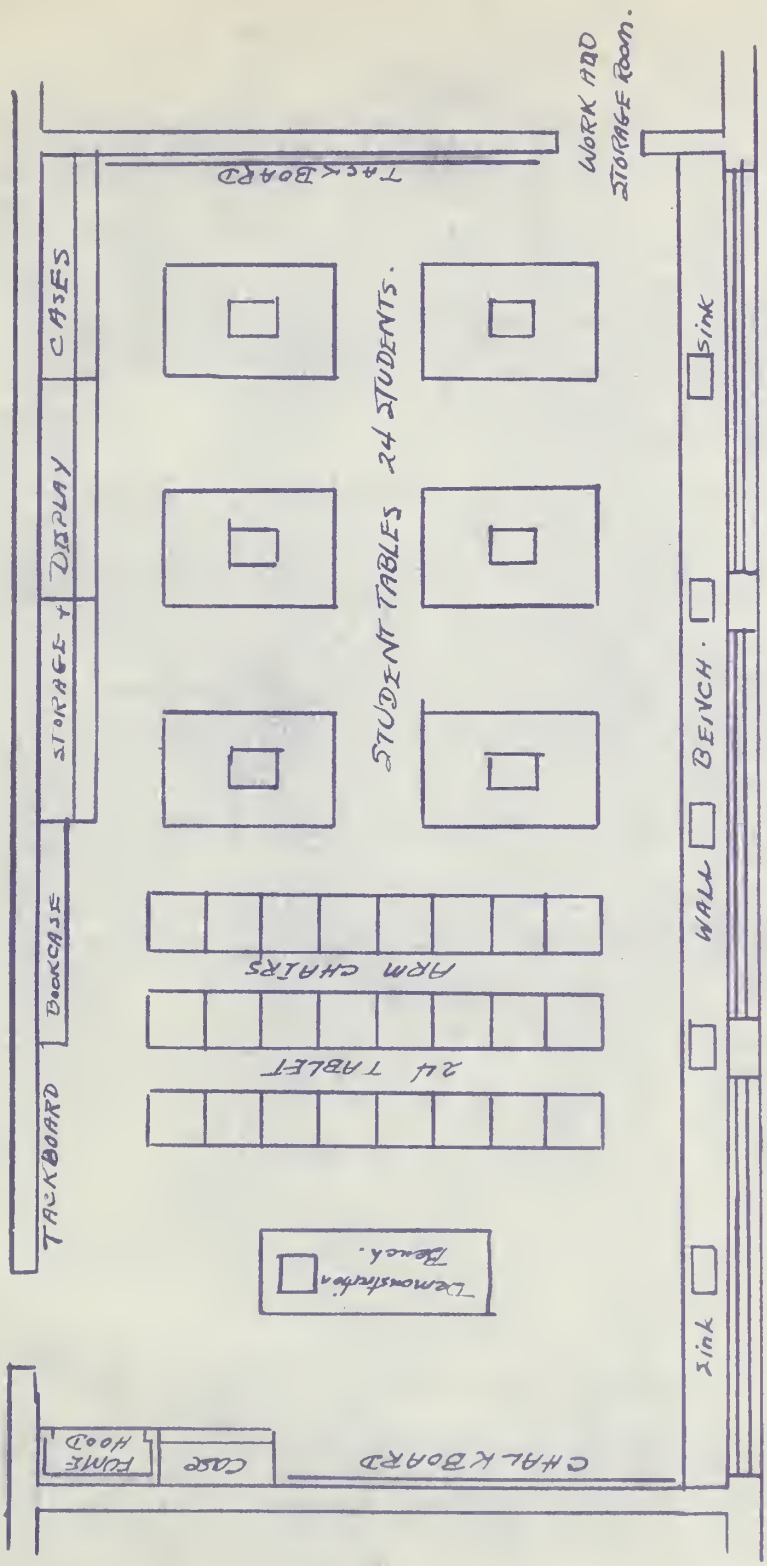
SIZE of SCHOOL - 200-449

FIGURE 5



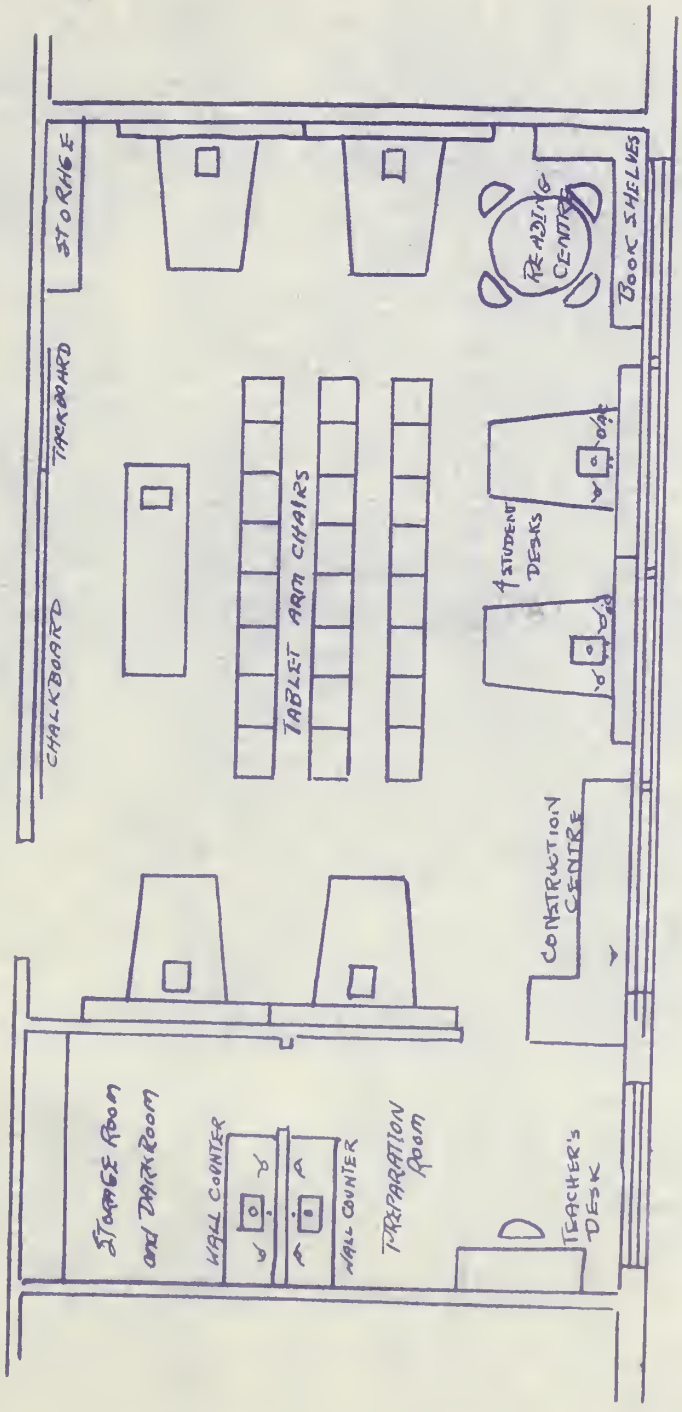
DESIGNATED CHEMISTRY AND PHYSICS LABORATORIES
SIZE OF SCHOOL: 200-499

FIGURE 6



Suggested combined classroom and laboratory for one teacher
Size 24'x 48'

FIGURE 7



Suggested combined classroom and laboratory. Another access door may be planned. Size 24'x46'.

FIGURE 8

B29807